Synchrotron Radiation Instrumentation
Collaborative Access Team

SRI CAT NEWSLETTER

Vol. 2, No. 3 January 1996

From the desk of the Executive Director:

The months of October and November were full of very significant events for SRI CAT. First of all, in October, SRI CAT staff members actively participated in the National Synchrotron Radiation Instrumentation Conference SRI-95 held at the APS. Four APSUO Workshops held in the framework of SRI-95 were chaired by SRI CAT members. These Workshops concentrated on the most recent developments of Synchrotron Radiation (SR) instrumentation and were a good opportunity for the SRI CAT to present the excellent results obtained with the very first APS SR beam. Part of these results are described in the current issue, and others were reported in the October issues of SRI CAT Newsletter and CAT Communicator.

Because of changes in the storage ring commissioning schedule, all of November was used by SRI CAT for the completion of important construction and installation milestones. By the end of November, all three Sectors of SRI CAT were equipped with IDs. Sectors 1 and 2 each now have a 3.3-cm undulator installed in them, and Sector 3 has a 2.7-cm device in place. Based on the magnetic measurement data for all three devices, excellent performance beyond specifications (the same as for Undulator A #2 tested at Sector 1) is guaranteed. The January 96 run, scheduled to start the second week of the month, is expected to be very fruitful for all of us.

In order to make it happen, a lot of construction and installation behind the shield wall was executed by SRI CAT members. In the October-November period, active integration of the beamline components in Sector 1 station 1-BM-A, as well as in the 1-ID-A and B stations, took place including installation and integration of commissioning windows, slits, monochromators, and other equipment. The testing of the BM beamline EPS is currently in progress. Also, construction of 1-BM-C is nearing completion. So, at the moment, both BM-A and ID-A and -B stations of Sector 1 are ready to accept the beam. Standard shielding verification will take place at the beginning of the run. After that, we will move on to planned experiments.

-Efim Gluskin, SRI CAT Director

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Status of the APS Accelerators

Introduction

The prime performance specifications of the APS storage ring (SR) are measured in terms of its energy, current, lifetime, emittance, orbit stability, and reliability. A rather comprehensive picture of the storage ring has been assembled during commissioning studies, indicating that performance goals for energy, emittance, and orbit stability have been met or exceeded. The goal for current stored in a single bunch has been exceeded by a factor of two, and the total current is at 70% of specification after about four shifts devoted to high-current studies. Beam lifetime is improving very rapidly with the accumulation of operating hours; a lifetime of 20 h was observed with 20 mA of beam stored in the September commissioning run. It is reasonable to expect that all performance specifications will be met early this winter, and efforts will continue to achieve improvements beyond specification in most measures mentioned above.

Energy and Current

The nominal operating energy of the SR, 7.0 GeV, is recognized by DOE as the design specification of the ring. Since April 1995, all commissioning studies have been carried out at this energy.

The DOE-recognized goal for stored current is 100 mA, which was achieved at APS on 12 Jan 1996. Evidence suggests that this limit will be exceeded when the constancy of the accelerating gradient in the rf cavities is improved by automatic controls. This belief will be tested in the next commissioning run.

The design goal for current stored in a single bunch has been 5 mA. To date, 9.7 mA has been stored. It may be possible to exceed this current with the above-mentioned automatic control of the rf systems. High-current bunches create electromagnetic fields in the beam pipe that have the effect of lengthening the bunch and reducing peak current. Measurements of bunch lengthening in the SR indicate that the amount of bunch lengthening is as expected.

Lifetime

Problems with leaking water cooling connections and short circuits of the distributed nonevaporable getter (NEG) pumps in the SR vacuum chambers prevented complete bakeout and pump down of the storage ring since January 1995. For this reason, beam lifetime was no more than 2-3 h at 5-10 mA throughout the summer. These two problems were fixed during the September 1995 shutdown. After bakeout, base pressure (pressure with no beam stored) was 0.3 nTorr or lower around the ring.

Beam lifetime depends on many parameters, including available rf voltage, vertical emittance, and current per bunch; however the most important parameter is pressure in the SR vacuum chamber with beam stored. The beam-driven pressure rise can be expected to improve over time as gas desorbed by synchrotron radiation is pumped away. This was evident in the September and October runs as lifetime increased from 10 h to 20 h with 20 mA beam. Further improvements, to 50-100 h, are to be expected in the near future. It should be kept in mind, however, that beam lifetimes are shorter when operating with high single-bunch current and smaller-than-specification vertical emittance; this is because particles are lost by intra-beam scattering as well as by scattering from residual gas.

Emittance and Orbit Stability

Measurements of particle beam emittance were carried out at 35-BM using visible light and at 1-ID by imaging undulator radiation. Results confirmed the design goal horizontal emittance of 8 nm-radians. The vertical emittance was measured at 2.5 nm-radian, about a factor of three smaller than specification.

In April 1995, measurements of orbit stability showed that the vertical beam motion was within specification at 4.5 μm RMS (1-20 Hz) while the horizontal motion was too large by a factor of 2, at 34 μm RMS. After ruling out many more likely candidates, the cause of the horizontal motion was tracked down to current fluctuations in a few of the sextupole magnets in the SR. After these fluctuations were eliminated, the horizontal beam motion was observed to be at specification. Slow

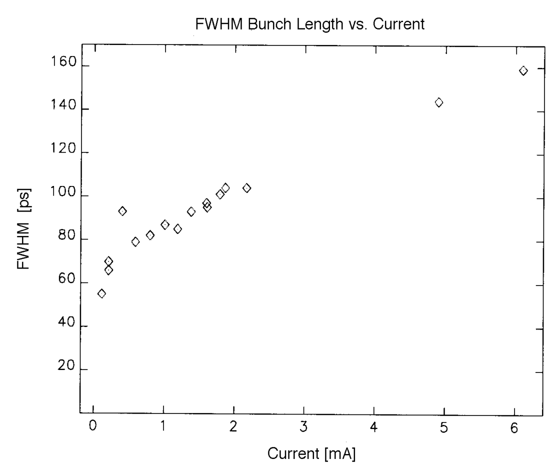

Figure 1. FWHM bunch length vs. current. (Accelerator Studies Logbook, shift 2, 10/15/95)

drift of the orbit, though not yet thoroughly studied, appears to be quite small.

Further improvements in orbit stability will be achieved when the feedback orbit control system is commissioned, starting in December. Slow drift should be reduced to the resolution limit of the beam position monitors, while higher frequency motions (up to 25 Hz) should be reduced significantly as well.

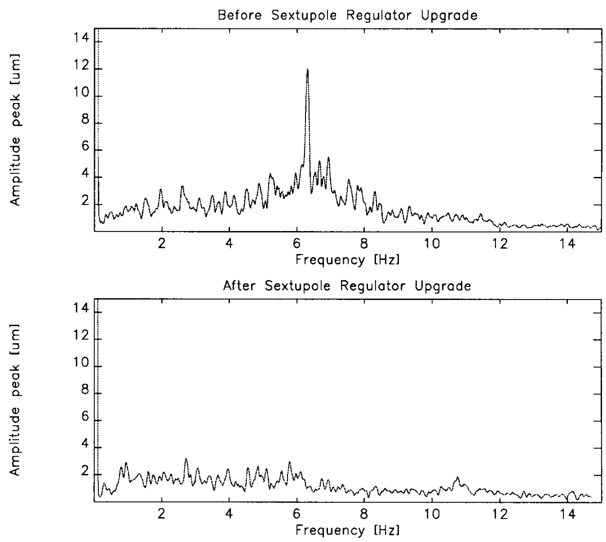

Figure 2. Horizontal orbit stability before and after the modification to the sextupole supply regulators. (Accelerator Studies Logbook, shift 2, 10/16/95)

Reliability and Beyond

Mature synchrotron radiation facilities achieve 95% availability, and APS should do likewise. A more challenging APS goal is 95% reliability in 24 hours (i.e., a 95% probability that the ring will run uninterrupted at specification in any scheduled 24 hour period). The SR is not near these goals yet, but considerable effort and funds have been invested in designing for reliability. For example, the APS accelerators have been designed to support operation with 300 mA at 7 GeV or 225 mA at 7.5 GeV. These design goals dictated generous safety factors for power supplies, rf systems and x-ray absorbers. In addition, plans call for standby hot spare rf transmitters in the SR and linac, so that operations can continue with one rf system off line for maintenance or repair.

While most groups in the Accelerator Systems Division (ASD) strive for high reliability in operations, the accelerator physicists will investigate improved operating configurations offering, for example, 4 nm-radian horizontal emittance, 0.1 nm-radian vertical emittance, and operation with good lifetime with 5-mm ID chambers installed. Most of all, I think I speak for all members of ASD in welcoming SRI-CAT and indeed all experimenters to the APS.We have invested a lot of effort and a bit of heart and soul in the accelerator systems, and we will work at making the APS perform at and beyond the expectations of the user community. *-John N. Galayda, APS Accelerator Systems Division*

First Light from an Undulator at the APS

The July ’95 commissioning run for the APS storage ring was originally planned to end on August 7, without an opportunity for testing an undulator. Indeed, no undulator had even been installed when the run began. However, as the end of the run approached, the storage ring was working well and it was decided to extend the run in order to try operating the first undulator at APS before beginning a long shutdown.

The storage ring had already been operating with a 12-mm-aperture insertion-device vacuum chamber, so only a brief (2-day) interruption in the run was needed to install the undulator, which was done on Aug. 2 and 3. As little as possible was changed in the rest of the storage ring in order to make sure the ring would continue to work well, and the ring was turned on again easily.

After the startup, some machine studies were carried out to determine orbit correction parameters that would make adjustments of the orbit through the ID more convenient, then on Aug. 5, it was time to close the undulator gap. No light was going to be extracted yet — instead, the effect of the undulator on the stored electron beam had to be studied first. The first experiment was to see if closing the undulator gap had an effect on the closed orbit of the stored beam. No effect was seen when the gap was first closed, so experiments were run driving the gap open and closed repeatedly while monitoring the beam position all around the ring. After enough statistics were gathered, a small motion of the stored beam due to the undulator could be distinguished from the noise. The horizontal motion of the beam was found to be as high as 3 to 5 microns in a number of places around the ring, while the vertical motion was below 0.5 micron almost everywhere. As a comparison, the beam size in the undulator straight section was measured (see below) to be 311 microns horizontally and 45 microns vertically, so the beam motion caused by the undulator is very much less than the beam size. This result is particularly encouraging because the beam position feedback system in the storage ring was not turned on during the experiments. It is a testament to the quality of the undulator fabrication and magnetic tuning and also bodes well for future operation of many undulators simultaneously.

The next day (Sunday, Aug. 6, 1995), measurements of the tune shift due to the undulator were made. Again, the undulator gap was scanned repeatedly between 15.7 mm and 40 mm, with the tune of the stored beam being measured at the extremes in gap. (Although the undulator can go to 200 mm gap, 40 mm was deemed large enough that, at least for these purposes, the undulator was effectively at open gap.) A tune shift due to the undulator was seen: at small gap, the tune was higher by 0.0004. Even a perfect undulator would show a tune shift, though, because the undulator field has a vertical focusing effect on the stored beam. For an ideal undulator, a tune shift of about 0.0009 would be expected.[1]

A few days later (on Wed., Aug. 9, 1995), everything was ready to extract the undulator's photon beam and a lot of people were present for the occasion. The first experiment was to close the undulator gap, while the photon shutters were open, with a fluorescent screen and closed-circuit camera ready so the beam could be seen. Monitors for the camera were connected both on the experiment hall floor and in the control room, so everyone present could watch. The undulator x-ray beam was very intense, even with only 0.5 mA of stored electron current. As the undulator gap reached 18 mm and before the photon shutter was closed, the observers could see irreversible changes occurring in the fluorescent screen as it suffered under the high power levels in the undulator beam.

After the excitement of "first beam" and the taking of many souvenir pictures of the beam using radiation-sensitive paper, it was time for more serious work. The first things that needed to be done were radiation shielding measurements. Those were reported by Dean Haeffner in the October 1995 SRI CAT Newsletter. Once the area was declared safe, XFD crews moved in to use the beam.

The suddenness of the decision to extend the commissioning run to include undulator tests provided a challenge for the experimental folks. The scientist who had built much of the equipment that would be used for the spectral measurements had just left on a long-delayed vacation home to Russia and wasn't scheduled to return until late August. When the undulator test was rescheduled, he couldn't get his plane ticket changed in time to make it back. However, other team members who had been involved in the previous tests of the equipment were able to set up for and make the measurements.

On Sat., Aug. 12, measurements were begun of the undulator beam, using a gas scattering spectrometer to measure its spectrum. As measurements were being made, the stored beam was lost a few times, but was rapidly reestablished each time. The experimental crew was pleased to find that the position of the photon beam was nicely consistent from fill to fill, so that not much time was lost in realigning at each fill. Time was also saved by having a terminal set up on the experiment hall floor that could control the undulator gap. While the gap had been controlled only from the main control room during all the earlier experiments involving the undulator, the accelerator physics crew had satisfied themselves that the undulator's effect on the storage ring was small and so allowed the experimenters to control their own undulator's gap. Work proceeded well into the evening, and Gopal Shenoy brought in pizzas for the whole crowd.

Over the next three days, the experiments to characterize the undulator radiation (more details of these are below) continued, but the audience grew. Bill Kurtis, who is well known to Chicago-area television news audiences, had sent a camera crew to film at the APS. The television crew had scheduled appointments with various people and parts of the APS project during the day and then joined the undulator characterization experiments in the evening. Another interested person present for the experiments was Dr. Kem Robinson, one of the owners of (and the undulator project head at) STI Optronics, the company that designed, built, and tuned the undulator being used, and that will build and tune all but one of the initial complement of insertion devices. The audience was well rewarded for their patience (the experiments didn't begin until mid-afternoon and ran late into the night) by being able to see the undulator spectrum as it was being measured out to higher and higher harmonics. Even then, it wasn't fully realized what was the highest harmonic seen. The highest harmonic seen using the crystal scattering spectrometer was originally thought to be the 16th, until all the scans were lined up together, showing that it was the 17th. Besides measuring the spectrum of the undulator radiation, experiments were carried out to measure the size of the beam. First, CCD pictures, then edge scans were taken.

During the XFD experiments, the operators and accelerator physicists operating the machines were very helpful. Running of the booster and of the storage ring was not yet routine enough for it to have been turned over to the machine operators. Whenever beam was injected, it had to be done with a booster expert and a storage ring expert there to run those machines. Since there weren't many experts like that, the responsibility fell on a very small number of people. They had already been through a long run and the last-minute extension of the run upset some of their plans. Nonetheless, they worked many hours beyond their scheduled shift times. On the last night of one run, the undulator characterization folks were working very hard and very late, trying to get as much done as possible. The hour got to be too late even for the accelerator physicists (after so many late nights in a row!) and they had to leave. The synchrotron radiation users were told that the ring would be filled one more time before the accelerator physicists left. The storage ring operations crew would maintain the stored beam as long as it lasted, but since they couldn't reinject, when the beam was gone, that was the end of the run. Experiments were run that night until after 4 am.

On Aug. 16th and 17th, a 5-meter-long, 8-mm-aperture insertion-device vacuum chamber (the “mature phase” chamber) was installed in Sector 3 (the insertion device and 12-mm chamber were in Sector 1). On Friday, Aug. 18, the ring was operated successfully once more, demonstrating that operation with the smaller-gap vacuum chamber was no problem.

During operation with the smaller vacuum chamber, some time was made available for synchrotron radiation users' experiments. During that time, more work was done on imaging the undulator beam and using it to determine the size of the stored electron beam. On Sunday afternoon, Aug. 20, the machine was shut down, and a long maintenance period began.

Results of Measurements[2]

The undulator used for these experiments was a standard Undulator A — a planar, permanent-magnet hybrid undulator with a 3.3-cm period. It is 2.4 m long, or 72 periods. At a minimum gap of 10.5 mm, the effective field of this particular undulator is 8950 Gauss. During these experiments, the minimum gap achievable was 15.7 mm, however, where the effective field is approximately 5.2 kG. The spectrum measurements were taken at an undulator gap of 15.8 mm.

At the time these experiments were run, testing had not yet been completed on some parts of the machine protection system that would help prevent damage to the storage ring if the electron beam through the undulator were badly missteered. Therefore, it was decided that whenever the undulator gap was anything less than fully open, there was not to be more than 1 mA of stored beam current. The results reported here were all obtained with less than 1 mA of stored beam.

Two main types of measurements were carried out: 1) measurements of the x-ray spectrum produced by the undulator, using two different techniques; and 2) measurements of the size of the x-ray beam, which were in turn used to determine the emittance (or, alternatively, the size and divergence) of the particle beam in the undulator.

Spectrometer Measurements

Two different techniques were used to measure the absolute spectral flux of undulator radiation. The first uses a gas-scattering spectrometer, which measures the x-rays scattered at 90° from a known volume of He gas at a controlled pressure. The spectrum of scattered radiation is recorded using an energy-dispersive Si(Li) detector and a calibrated multichannel analyzer. The entire spectrum is collected at once. This spectrometer is used for x-rays in the energy range of 5 to 45 keV. By paying careful attention to detector efficiencies, gas volume, etc.,[2] absolute flux measurements can be made. This technique has the advantages that it is fast and can be used even for higher stored beam currents when power loading is high.

The second technique uses a crystal spectrometer to measure the spectrum. The x-rays are diffracted from a Si(111) crystal into an ion chamber detector. Again, it is necessary to determine the efficiency of the detector and characterize the Si crystal so that absolute flux measurements can be made. Measurements using this spectrometer are slower than with the gas-scattering one, but better energy resolution is achievable and much higher photon energies can be reached.

The first spectral measurements were made using the gas-scattering spectrometer. It was very exciting to see a sharp harmonic structure appearing as the multichannel analyzer accumulated counts. As these measurements were being made, preliminary calculations of the expected spectrum were being performed on another workstation that had been moved to the experimental area for the occasion. The calculations would eventually be made with the measured magnetic field profile of the undulator but, for the first quick results, a sinusoidal approximation of the field was used. The calculations also needed various electron beam characteristics. At the time that the data were being taken, the emittance of the particle beam had not yet been measured and there was much discussion about what coupling should be used between the vertical and horizontal emittances. Calculations were made using a variety of assumptions, and the preliminary results were very encouraging. After the emittance measurements were made (see below), more rigorous comparisons could be made. Fig. 1 shows the spectrum measured using the gas-scattering spectrometer, along with the calculated spectrum. Six sharp harmonic peaks are clearly visible. The calculation used the measured on-axis undulator magnetic field (corrected to a gap of 15.8 mm), the measured electron beam emittance, and an electron beam energy spread of 0.1%. The result was then convoluted

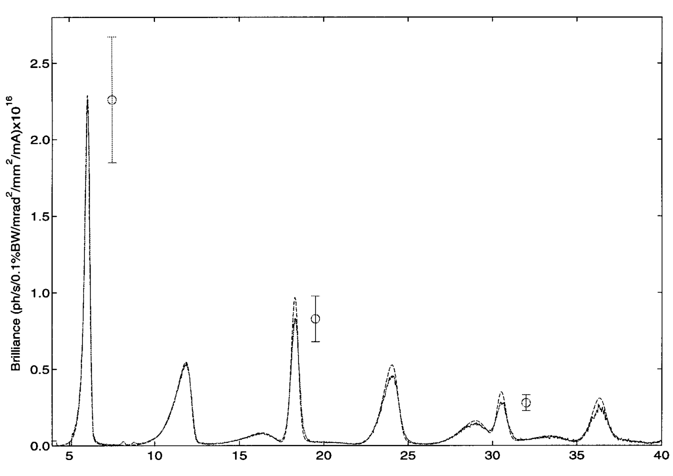

Fig. 1. Measured on-axis spectral brilliance (solid line), using the gas-scattering spectrometer, and calculated on-axis spectral brilliance (dotted line) of the undulator radiation from a 7-GeV electron beam at a gap of 15.8 mm (K=1.61). The calculation included the measured magnetic field of the undulator, the measured electron beam emittance (e_x=6.9 nm-rad, e_y=0.2 nm-rad), and the design value for the electron beam energy spread (0.1%). The calculated spectral brilliance was further convolved with the energy broadening functions mentioned in the text. The measured spectrum has been corrected for the Compton shift.

with energy-broadening functions to include the broadening effects of the detector response function, the Compton profile, and the finite detector acceptance angle. As can be seen in Fig. 1, the measured and calculated spectral brilliances are in remarkably good agreement.

After seeing sharp harmonics out to 40 keV, folks were eager to see what the spectrum looked like with better resolution and out to higher energies, so measurements using the crystal spectrometer began. A scan taken over the same energy range as that in Fig. 1 is shown in Fig. 2. The contributions from higher order reflections from the crystal were removed from the data. Also shown in Fig. 2 are the results of a calculation similar to that in Fig. 1. Note that the peak brilliance is higher than in Fig. 1 due to the smaller instrumental broadening with the crystal spectrometer. As with the gas-scattering spectrometer results, there is remarkably good agreement between the measured and calculated spectra.

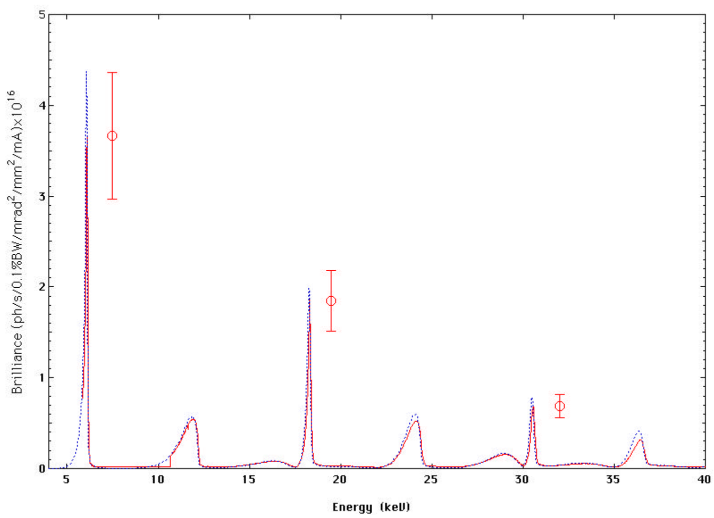

Fig. 2. Measured on-axis spectral brilliance (solid line), using the crystal spectrometer, and calculated on-axis spectral brilliance (dotted line) of the undulator radiation from a 7-GeV electron beam at a gap of 15.8 mm (K=1.61). The calculation included the measured magnetic field of the undulator, the measured electron beam emittance (e_x=6.8 nm-rad, e_y=0.2 nm-rad), and the design value of the electron beam energy spread (0.1%).

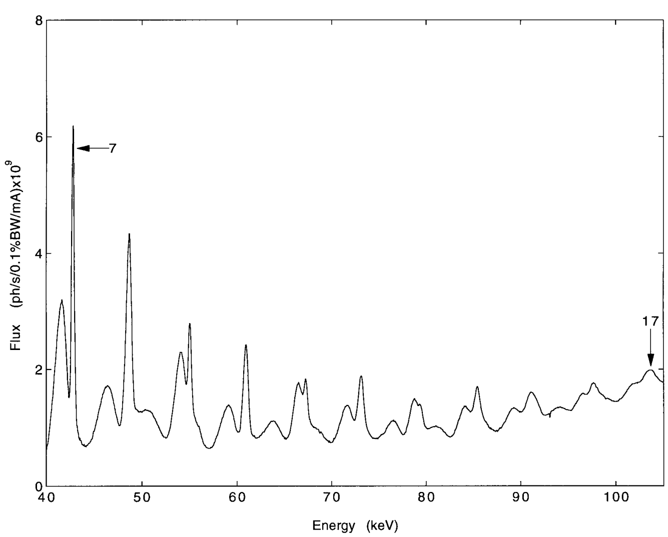

Fig. 3. Measured on-axis spectral flux of the undulator radiation, using the crystal spectrometer, from a 7-GeV electron beam at a gap of 15.8 mm (K=1.61). Undulator harmonics from the 7th to the 17th are clearly visible.

The crystal spectrometer was then used to look at the harmonic structure in the x-ray spectrum out to higher photon energies. Scans were taken through one range of crystal scattering angles after another, with higher and higher harmonics appearing. Finally, the upper limit for that crystal and geometry were reached at just above 100 keV. The results are shown in Fig. 3, where the 7th through 17th harmonics can be seen.

Electron Beam Emittance Measurements

The emittance of the particle beam is the product of the beam size and divergence. It can be determined through the effect it has on the size of the x-ray beam. Experiments were carried out to determine the x-ray beam size, which is related to the particle beam properties by:

$$\sigma_m^2 = \sigma_y^2 + (D\sigma_{y'})^2 + (D\sigma_{r'})^2 + (a_y/3)^2,$$

where σ_m is the rms vertical beam size at a distance D from the source; σ_y and $\sigma_{y'}$ are, respectively, the particle beam size and particle beam divergence; and $\sigma_{r'}$ is the undulator radiation opening angle. The term with $a_y/3$ is the contribution due to a slit of width a_y. The emittance, particle beam size and divergence are related by:

$$\sigma_y = \sqrt{\varepsilon_y \beta_y} \quad , \quad \sigma_{y'} = \sqrt{\varepsilon_y / \beta_y} \quad ,$$

where β_y is the betatron function and is, by design, nearly constant along the length of the undulator with a value of 10 m. The measurements were made at D=32.8 m, where the particle beam divergence contributes more to the photon beam size than does the particle beam size. The third harmonic was used so as to minimize the contribution of

σ_r' as compared to $\sigma_{y'}$. The crystal was tuned to diffract 18.37-keV x-rays, and the photon beam size was measured to be 0.179 mm. This beam size gives a vertical emittance for the particle beam of ε_y=0.20±0.04 nm-rad, corresponding to σ_y=45 µm and $\sigma_{y'}$=4.5 µrad.

A similar procedure for the measured horizontal beam profile resulted in a horizontal emittance of 6.9±1.0 nm-rad, corresponding to σ_x=346 µm and $\sigma_{x'}$=20 µrad for an experimentally-determined β_x value of 17.3 m. Thus, the emittance coupling $\varepsilon_y/\varepsilon_x$ is less than 3%, considerably less than the design value of 10%.

The measurement of the source size σ_x and σ_y was confirmed by a separate experiment in which the particle beam was imaged by a zone plate onto a CCD x-ray camera. From those measurements, σ_x was determined to be 346±35 µm and σ_y to be 109 (+0,-63) µm. This number for σ_y is an upper bound due to the limited spatial resolution of the CCD camera. The measured value of σ_x was used to determine the value of β_x given above. In future experiments, the CCD camera measurements will be supplemented by high-resolution knife-edge scans to determine the vertical image size more precisely.

Conclusion

The undulator as delivered by STI Optronics more than met our demanding requirements for integrals of the magnetic field and for phase error through the undulator. Some subsequent fine tuning of the gap dependence of the magnetic field integrals at APS improved the undulator still further. The small effect that moving the undulator gap had on the stored electron beam shows that the field integrals through the undulator are indeed quite small. This result is very promising for future free operation of insertion devices by users. The superb agreement between the calculated spectrum and the measured spectrum show that the magnetic measurements of the undulator are accurate, and that the parameters of the stored beam are well understood. The sharpness of the harmonic structure, even out to high harmonics, shows that the phase error in the undulator is small and that the stored beam is of high quality, both of which are required for high-brilliance x-ray beams.

These results for the first operation of an undulator at APS are the result of the efforts of a large number of people, from those who designed, built, tuned, installed, etc., the undulator and its vacuum chamber, to those who made the storage ring work as well as it did, to those responsible for the equipment and the measurements to characterize the emitted light. Any attempt to list them all would inevitably omit many of them and would occupy more space than available. *—Liz Moog, Zhonghou Cai, Roger Dejus, Peter Ilinski, Barry Lai, Dan Legnini, Wenbing Yun, APS Experimental Facilities Division*

References

1. Glenn Decker, personal communication; and J. B. Murphy, “Synchrotron Light Source Data Book,” BNL 42333 informal report, Version 3.0 (Oct. 1993), p. 31.
2. Details of these measurements will be published as “APS Undulator Radiation - First Results,” by Z. Cai, R.J. Dejus, P. Den Hartog, Y. Feng, E. Gluskin, D. Haeffner, P. Ilinski, B. Lai, D. Legnini, E.R. Moog, S. Shastri, E. Trakhtenberg, I. Vasserman, and W. Yun, to appear in the proceedings of the Synchrotron Radiation Instrumentation conference, held Oct. 17-20, 1995, Argonne.

Who’s New

Yonglin Qian - Postdoctoral Fellow

Dr. Yonglin Qian has joined Sector 2 as a postdoctoral fellow, where he will primarily work on x-ray phase contrast microscopy experiments. Dr. Qian, educated at Beijing and Northwestern Universities, brings to the APS considerable experience in x-ray scattering, standing wave, and spectroscopy physics. He has also logged many hours at the NSLS, where he conducted much of his doctoral research.

Heung-Rae Lee - Postdoctoral Fellow

Dr. Heung-Rae Lee has also joined Sector 2 as a ‘postdoc’. Dr. Lee’s expertise is in x-ray microscopy and microtomography, from extensive work in the X-ray Laser Program at Lawrence Livermore National Laboratory, and experiments at the NSLS. Dr. Lee studied at the University of California at Berkeley and did his graduate work at U.C. Davis.

Publications

P. K. Job and H. J. Moe, "Dose Rate Estimates in the First Optical Enclosure due to Particle Beam Loss in the Insertion Device Transition Region during Injection", ANL Report **LS-243** (1995)

J. C. Lang, G. Srajer, and R J. Dejus, "A Comparison of an Elliptical Multipole Wiggler and Crystal Optics for the Production of Circularly Polarized X-rays", ANL Report **LS-245** (1995)

P. B. Fernandez, "Silicon Bonding Techniques for X-ray Optics", ANL Report **LS-249** (1995)

W.-K. Lee, P. B. Fernandez, T. Graber, and L. Assoufid, "High-Heat-Load Synchrotron Tests of Room-Temperature Silicon Crystal Monochromators at the CHESS F-2 Wiggler Station", ANL Report **LS-250** (1995)

Y. P. Feng, B. Lai, I. McNulty, R. J. Dejus, K. J. Randall, and W. Yun, "Beam Transport Radiation Shielding for Branch Lines 2-ID-B and 2-ID-C," ANL Report **LS-251** (1995)

D. Frachon, I. Vasserman, P. M. Ivanov, E. A. Medvedko, E. Gluskin and N. A. Vinokurov, "Magnetic Measurements of the Elliptical Multipole Wiggler Prototype", **ANL/APS/TB-22** (1995)

R. C. Blasdell, L. A. Assoufid, D. M. Mills, "Diamond Monochromators for APS Undulator-A Beamlines", **ANL/APS/TB-24** (1995)

W. S. Haddad, J. E. Trebes, D. M. Goodman, H.-R. Lee, I. McNulty, E. H. Anderson, and A. O. Zalensky, "Ultrahigh-resolution soft x-ray tomography", *SPIE Proc.* **2516**, 102 (1995)

I. McNulty, Y. P. Feng, W. S. Haddad, and J. E. Trebes, "Tomographic scanning microscope for 1-4 KeV x-rays", *SPIE Proc.* **2516**, 217 (1995)

Safety Notes

MATERIAL SAFETY DATA SHEETS UPDATE

As a direct result of the requirements found in OSHA's Hazard Communication Standard, material safety data sheets (MSDSs) have become the most frequently consulted method chemical manufacturers have to provide information on chemical hazards to employers. At ANL, MSDSs are one of the primary sources used by many principal investigators attempting to find chemicals that pose a low level of risk and to identify hazards and appropriate precautions to be communicated to other persons using such chemical(s). Although the OSHA rule requiring manufacturers to provide accurate MSDSs has been in effect for over a decade, recent evaluations of MSDSs suggest continuing problems with the reliability of the information they contain.

Most recently, an Army Industrial Hygiene newsletter reported that only 11% of 150 reviewed data sheets provided accurate and complete information in four critical categories: health effects, personnel protective equipment, exposure limits, and first aid measures. Fifty-one percent of the data sheets were at least partially accurate in all four categories. The study supported results of two other major studies conducted in 1988 and 1990. Other major findings were: (1) only 37% of the data sheets had accurate health effects information, (2) 47% included accurate personnel protective equipment information, (3) 47% had accurate occupational exposure limit information, and (4) 76% had accurate first aid information. The study indicated that many of the inaccuracies consisted more of a lack of details or omitted information rather than incorrect data.

The Hazard Communication Standard requires chemical manufacturers to provide new and updated data sheets to their distributors who, in turn, must provide them to their customers when shipping those chemicals; therefore, a considerable time lag may occur before a researcher receives a new or updated data sheet. Indeed, since distributors are only required to provide one copy to an employer -- in our case, Argonne National Laboratory -- a researcher might not even receive a current MSDS with the shipment of a chemical.

To minimize the uncertainties associated with MSDSs, the Experimental Facilities Division should employ the capabilities described below.

- If the accuracy of a material safety data sheet is in question, XFD personnel should inform the ES&H Coordinator, who will contact the distributor or manufacturer to obtain a current MSDS and to resolve uncertainties.
- Personnel seeking to order a new chemical, i.e., one not already in stock and being used by the same personnel in a previously reviewed operation, must first obtain a copy of the substance's MSDS, review it to ensure that adequate hazard controls are available, provide for controls that are missing, and forward a copy to the XFD ES&H Coordinator, who will evaluate the adequacy of personnel protective equipment for that chemical. Only after such an evaluation will the purchase be authorized.
- Personnel receiving an MSDS with a shipment should provide a copy to XFD's Chemical Tracking System Representative, Meg Noreuil, who will, in turn, make sure that it is the latest available version and that it is included in ANL's collection.

ANL's ESH-IH Section maintains up-to-date copies of MSDSs for thousands of chemicals used at the laboratory. Meg Noreuil (ES&H Administrative Assistant, Bldg. 401; rm. B1162; ext. 2-2787) has on-line access to these MSDSs and will print copies for interested persons. *-Bruce Stockmeier, XFD ES&H Coordinator*